DAMOP12-2012-000018

Abstract for an Invited Paper
for the DAMOP12 Meeting of
the American Physical Society

Quantum feedback experiments with atoms and cavities

JEAN-MICHEL RAIMOND[1], Université Pierre et Marie Curie

Quantum feedback transposes the usual feedback loop concept into the quantum world. A measurement performed on the system by the sensor is used by a controller to infer the system's state and to steer it towards the target by the action of the actuator. This scheme has to face a fundamental difficulty, since the measurement changes the system's state. This back-action makes quantum feedback algorithms more complex than their classical counterparts. We report the first successful operation of a repeated quantum feedback loop [1]. It prepares photon number states (from 0 to 4 photons) on-demand in a superconducting microwave cavity and subsequently reverses the effect of decoherence-induced quantum jumps. The quantum sensors are circular Rydberg atoms, performing a Quantum Non Demolition (QND) measurement of the cavity field. Information they provide is used by the controller (real-time computer) to estimate the field state. The controller determines the amplitude of a coherent displacement leading the cavity closer to the target This displacement is performed by a microwave source acting as the actuator. Iterations of this loop rapidly drive the cavity towards the prescribed target. When it is reached, the actuator idles. It resumes operation when atomic detections indicate that a photon has been lost, or that a thermal photon has appeared. The feedback compensates for these quantum jumps and rapidly restores the field in the target state. In a variant of the experiment, we use quantum actuators, resonant atoms that feed photons back in the cavity when they get lost. This more efficient scheme allows us to stabilize higher photon numbers. These experiments are a first step towards the use of quantum feedback to protect fragile quantum resources. We also consider an alternative route towards state protection based on reservoir engineering [2].

[1] C. Sayrin et al. Nature (London) 477, 73 (2011)
[2] A. Sarlette et al. Phys. Rev. Lett. **107,** 010402 (2011)

[1]Laboratoire Kastler Brossel, ENS, CNRS, UMPC 24 tue Lhomond, F-75005 Paris France